BIBLIOGRAPHY OF THE IXODIPHAGINI (HYMENOPTERA, CHALCIDOIDEA, ENCYRTIDAE), PARASITES OF TICKS (ACARI, IXODIDAE), WITH NOTES ON THEIR BIOLOGY

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ABSTRACT

A bibliography is presented of the Ixodiphagini, poorly known specialist parasitoids of ixodid ticks. Their larvae develop in the host, largely on vertebrate blood. Notes are given on the taxonomy of the group and their occurrence in Europe. Their biology is described.

INTRODUCTION

The Ixodiphagini are a small tribe of morphologically unremarkable Encyrtids (figs. 1 and 2). Unlike other Encyrtids, however, they are internal parasites of hard ticks (Acari : Ixodidae). Several hymenopteran families contain species that parasitize arthropods that are not insects, but the Ixodiphagini are unusual because their larvae consume the vertebrate blood ingested by the host tick. This diet is unique among the parasitic Chalcidoidea.

Tick physiology and ecology are different from those of insects and the ixodiphagine acaroparasitoids show interesting adaptations to their tick hosts. Because the group is not well known, and the literature is scattered and difficult to trace, these notes and bibliography are offered as a stimulus to new research.

TAXONOMY AND BIOLOGY

There are currently seven species named in the Ixodiphagini, all of which are now assigned to the genus *Ixodiphagus* Howard, 1907 (Trjapitzin, 1985). Formerly they were separated into the genera *Ixodiphagus* and *Hunterellus* Howard, 1908 (Gahan, 1934; Quaraishi, 1958). The present species names probably conceal considerable diversity. Morphological and behavioural differences exist between *I. texanus* Howard, 1907 populations from the United States of America (Bowman, 1979), and from Canada (Davis and Campbell, 1979). Similar differences are recorded among the Indian *I. hookeri* (Howard, 1908) (Geevarghese and Dhanda, 1983), and European *I. hookeri* may differ from American representatives of the species.

Species are known from all zoological regions (Cole, 1965; Noyes and Hayat, 1984; Trjapitzin and Gordh, 1978). Only one species, *I. hookeri*, is recorded from Europe: from Britain (Burtt, 1943; Noyes, 1977), Czechoslovakia (Boucek and Cerny, 1954), France (Brumpt, 1930; Du Buysson, 1912), and the Soviet Union (Nikolskaya, 1952). The African species *I. theilerae* (Fielder, 1953), however, has been collected in Egypt on birds migrating to Europe (Kaiser and Hoogstraal, 1958; Hoogstraal and Kaiser, 1961). This species therefore may occasionally enter Europe.

The behaviour of the Ixodiphagini has been little studied except in the two American species *I. hookeri* and *I. texanus*. Least well known is how the female parasites find their hosts. Females have been seen in the fur of animals (Philip, 1931). They may therefore first search for the prey animal of the tick. The ticks would then be found and parasitized whilst they were still attached. All the ixodiphagines studied are able to oviposit in recently detached fully fed ticks. *I. hookeri* from the western U.S.A. (Cooley and Kohls, 1928), and from France (Brumpt, 1930), will also oviposit in unattached unfed hosts.

The host ranges of the Ixodiphagini are unknown. Taxonomic uncertainty among the parasitoids obscures the true acceptability of tick species as hosts for particular ixodiphagines. Some host specificity exists among the Indian species (Geevarghese and Dhanda, 1983). In

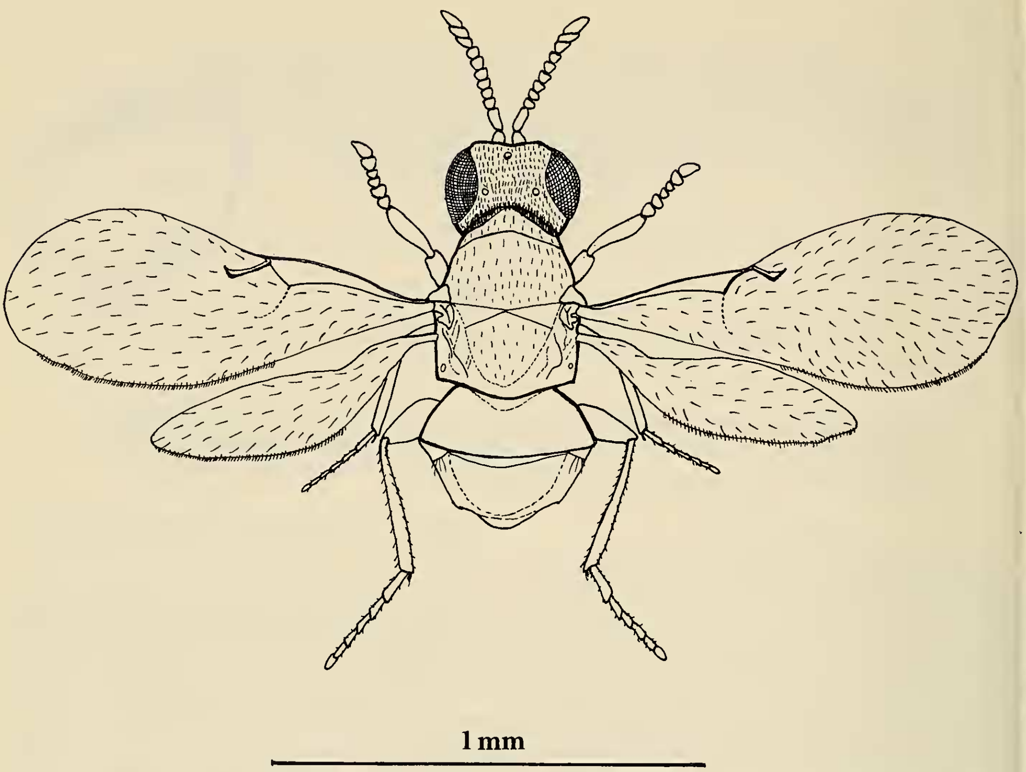

Fig. 1. *Ixodiphagus hookeri* (Howard, 1908), female from Czechoslovakia. Redrawn after Boucek and Cerny, 1954.

Nova Scotia, Canada, *I. texanus* emerged from only one of several tick species collected in the field. In the laboratory I was unable to obtain parasitization of any additional potential host species. Females of this strain of *I. texanus* have a complex sequence of host acceptance behaviour. They begin the sequence by antennating any rounded object, but oviposition is only completed on fully fed larvae and nymphs of one species. In Oklahoma, U.S.A., however, the same species parasitizes several tick species (Bowman, 1979).

The Ixodiphagini are not known to oviposit in adult ticks, whether these are fed or unfed, and most identified species oviposit and develop only in the nymphal stage of the host. *I. texanus* in Canada develops in fully fed larvae as well as nymphs (Davis and Campbell, 1979). In the U.S.A. the same species will also oviposit in unfed nymphs (Bowman, 1979). *I. hookeri* oviposits in fed and unfed larval and nymphal hosts, but development only occurs in the fully fed nymphs. This behaviour is known for material from Europe (Brumpt, 1930) and from America (Cooley and Kohls, 1934).

Several eggs are laid during a single oviposition and the larvae develop gregariously. In the laboratory there is no apparent obstacle to simultaneous or subsequent superparasitism.

After detaching from its prey the tick enters the ground litter. At this stage apolysis occurs in the tick and this may stimulate hatching, or development, of the parasites. As the ixodiphagine larvae grow the external appearance of the tick shows characteristic changes (Wood, 1911). The duration of larval life depends on temperature, and on whether or not the tick diapauses.

Adult parasitoids usually emerge from a single hole chewed at the rear of the tick (Davis and Campbell, 1979) where the cuticle is thinnest. Males tend to emerge first and copulation takes place near the host remains. Females disperse rapidly after mating.

More adults emerge from large than from small hosts, although adult size appears to be

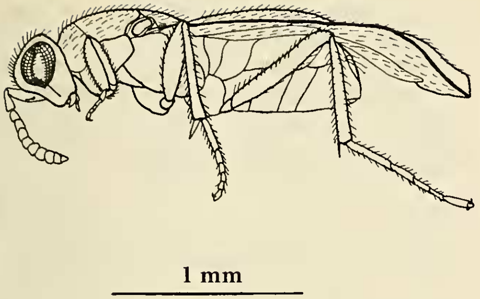

Fig. 2. *Ixodiphagus hirtus* Nikolskaya, 1950, female from the Far Eastern U.S.S.R. Redrawn from Trjapitzin, 1985.

negatively correlated with brood size. Broods from large hosts have, in general, a lower proportion of males. These relationships exist in one species, *I. texanus* (Dean, 1982), and also appear to hold across the Ixodiphagini as a whole.

NOTES

This bibliography contains over 135 publications on the genera *Ixodiphagus* and *Hunterellus*, all members of which are internal gregarious parasitoids of ticks (Acari, Ixodidae).

The publications are listed alphabetically by author and each entry includes the full title, full journal title and pagination. Where the article contains a large number of pages, those referring directly to the Ixodiphagini are listed in parentheses immediately after the full reference. In square brackets after each entry is given the original language of the article followed by the language of any translation in my possession. The initials AUIC indicate translations made under my auspices and the number following them is the index number of the translation in my collection. NAMRU3 refers to translations made, or held, by the Medical Zoology Department, American Naval Medical Unit Number 3, Embassy of the United States of America, Cairo, Egypt. It is followed by the number referencing the translation in their library. Where both an AUIC and a NAMRU3 translation are listed, they both usually originate from AUIC.

I have not been able to obtain copies, or trace the whereabouts, of those entries preceded by an asterisk (*).

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M. Wilbraham and J. Law prepared the figures.

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